In South Dakota 5 of the 23 years have departures of like sign; but in this case also the departures are small, and the correlation coefficient is greater than in North Dakota, being −0.73, with a possible error of 0.07. The coefficient expressing the relation between precipitation and yield was previously found to be 0.59, and the possible error 0.06. Of the 5 years with departures of like sign, 3 are with temperature and yield both above normal and 2 with both below. Likewise there are 5 years when precipitation and yield fail to show their expected relation, 1 wet year with a small yield, and 4 dry years with high yields. In this State, also, May and July temperatures are apparently without significance in this connection. In both States the cool and wet years are undoubtedly the most favorable, but in South Dakota the greatest yield was in a cool and dry year. On the whole, the cool and dry years appear somewhat more favorable than warm and wet years, but the number of observations of these conditions is rather limited. Similar tables for Minnesota gave small coefficients and indicated no definite correlation.

Considering only calendar months, the rainfall of May and June and the mean temperature of June are the important weather factors, and they are of about equal importance, affecting the wheat crop of the Dakotas.

REFERENCES.

(1) MONTHLY WEATHER REVIEW, October, 1913, **41**: 1515–1517.
(2) **Abbe, C.** First Report on Climate and Crops (Weather Bureau Bulletin **36**), p. 316.
(3) **Hunt.** The Cereals in America.

AN EIGHT-DAY MECHANICALLY RECORDING RAINGAGE.[1]

By CHARLES F. MARVIN, Chief of Bureau.

[Dated, Weather Bureau, Washington, D. C., Jan. 23, 1915.]

The tipping-bucket raingage permits of a great refinement and accuracy of record, and is probably the best device available for securing rainfall records at the regular Weather Bureau stations. There is, however, a widespread need for a thoroughly reliable gage of ample capacity, complete in itself, involving no troublesome electrical arrangements for registration, and finally providing a record covering a considerable period of time. Early in 1913 the author undertook to design a weekly gage of the float type to meet such requirements; a model was constructed, and the success of the tests has since justified the purchase of a number of these gages for use in the Weather Bureau service. They will find an extended use in the studies of rainfall in connection with many projects wherein the *rate* of rainfall is an important factor.

Wind shields of the Nipher type are provided, which we hope will assist in obtaining the true catch even on occasions when the wind velocity is considerable.

Description.—The photograph reproduced in figure 1 shows the complete gage. The circular collector, *A*, is exactly 8 inches inside diameter across its sharpened (beveled) brass rim, and is surrounded by the rectangular wind shield, *B*. This shield is nearly 21 inches square at its upper edge and curves downward and inward to the copper cover, *C*, to which it is screwed. The cover is about 15 inches square inside and supports the 8-inch collector, the two together forming the top. The cover is ordinarily hinged to the top plate of the support, *E*, and is locked in position by a small bolt. The support, *E*, which is a little over 2 feet high, is made up of two iron castings; the upper casting carries the recording apparatus and the top, and the lower one forms the base for the receiver, *D*. The two castings are connected at the center by a 1¼-inch pipe, which also serves to inclose a small brass counterweight. The posts of the support, *E*, are four small iron pipes, which are screwed into the upper casting at its corners and fastened to the lower casting by means of set screws. The lower ends of the corner posts form feet for the gage.

Figures 2 and 3 illustrate the recording apparatus in detail. The registration is a record of the motion of a float upon the surface of the water in the receiver, *D*. To eliminate inaccuracies and uncertainties, the float is suspended by means of a fine flexible brass chain, such as jewelers use, permanently attached to one end of the drum, *H*. When the float rises, the chain is wound up by the pull of the counterweight suspended from a length of silk cord, also fastened to and wound up on the drum, *H*. The chain and cord run in a shallow screw thread cut in the drum, the chain winding up as the cord unwinds, and vice versa. The chain eliminates possibilities of variation of length, such as would be caused by moisture and stretching should a cord be used, and its permanent attachment to the drum, *H*, makes slipping impossible.

The cam shaft, *I*, carrying the drum, *H*, turns once for each one-half inch of rainfall and revolves a cylindrical cam, *K*, made to turn with the shaft, *I*, but free to slide endwise at the same time. The pen and pen lever are shown at *S* and *L*, respectively. The pen carrier, *T*, is mounted on the long screw, *N*, and guided by the rod, *U*. The motion of the pen is somewhat complex, but the arrangement is one that affords the maximum of clearness of records of excessive rates of precipitation, and at the same time the minimum of size of record sheets. Nearly all other automatic gages with records on a large scale require very large sheets that must be changed after a relatively moderate amount of rain has been recorded thereon. In this gage the rise of the float in the manner already explained rotates the cam, *K*, which in turn causes the pen to oscillate laterally over an extreme range of one-half inch on the record sheet. This amount of motion, over and back, represents one-half inch of rain. The record sheet has one-tenth-inch rulings, each subdivision represents 0.05 of an inch of rainfall and permits of very satisfactory estimates to hundredths of inches. The apparent impossibility of any kind of accumulative error in this gage makes its records more reliable than gages of the tipping-bucket type.

The adoption of an oscillating motion for the pen permits a large amount of precipitation to be recorded in a narrow band one-half inch wide across the record sheet. The remainder of the sheet is made available for additional record simply by causing the pen carrier to move laterally by the action of the clock, at the rate of one-half inch per revolution of the drum. Thus each day's record (one revolution of the drum) occupies only a transverse space on the record sheet one-half inch wide. Each sheet provides a record for eight days. The reason for adopting an 8-day record is that four sheets will suffice for a full record for each and every month. Instruments using only 7-day or weekly record sheets require five sheets for a month's record with only little on one of the sheets. The record cylinder, *F*, is 6 inches in diameter outside, and $5\frac{7}{16}$ inches in length over all, and it is made to revolve on the axle, *R*, by a clock which is entirely

[1] *See* Weather Bureau Instrument Division Circular E, 3d ed., App. 2. Washington, 1915.

To face p. 26.

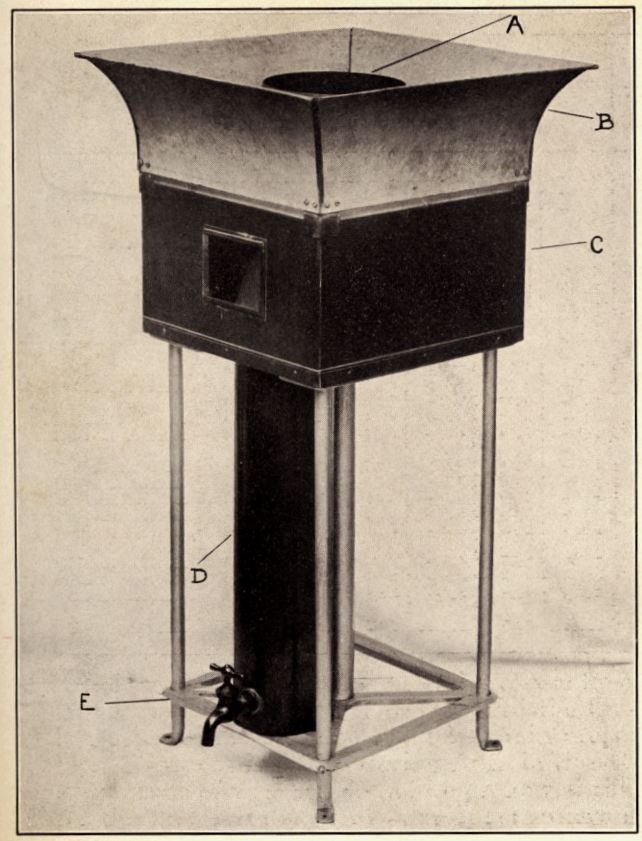

FIG. 1.—Marvin 8-day recording raingage, complete.

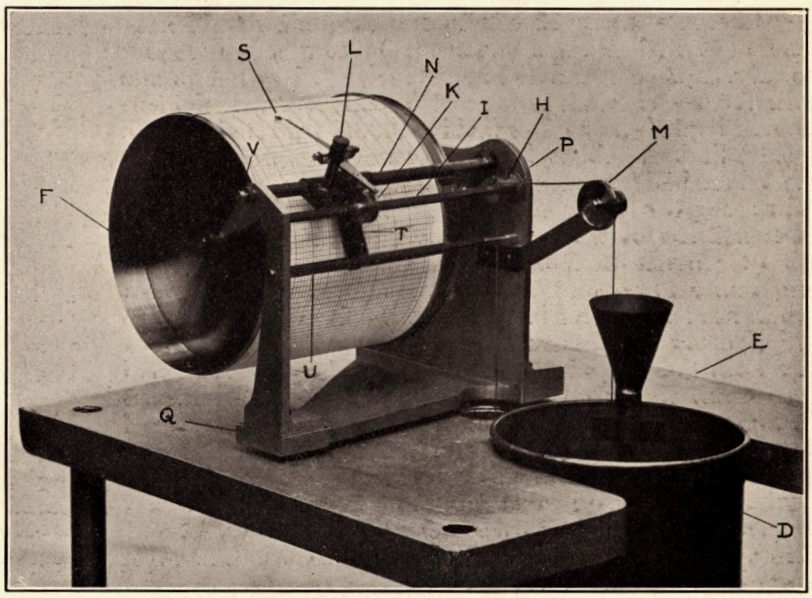

Fig. 2.—Recording mechanism of Marvin recording raingage, showing pen in position on sheet.

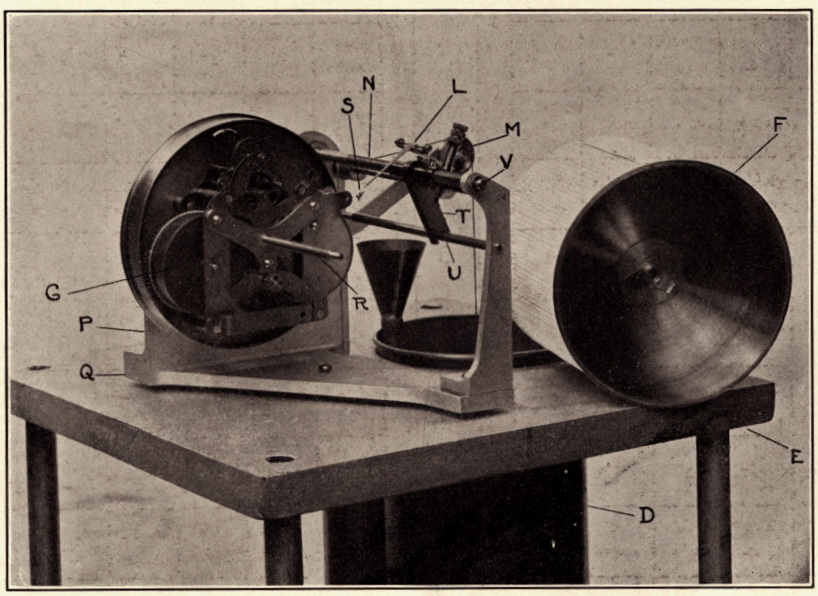

FIG. 3.—Recording mechanism of Marvin raingage with the record cylinder removed and showing clock.

inclosed and protected from dust and moisture when the cylinder is in place.

Operation.—The rainfall caught in the 8-inch collector (*A*, fig. 1) passes through a funnel and a small pipe as shown in figure 2, to the bottom of the cylindrical receiver, *D*, which has half the sectional area of the receiver, *A*. The depth of rainfall is therefore only doubled for measurement. Receiver *D* has a capacity for nearly 10 inches of rainfall, and may be conveniently emptied by the aid of the spigot provided. This has a siphonlike extension, inside the receiver, that permits the surplus water within to be drawn off to a certain zero level, but leaves remaining not only a small quantity of water but especially a surface layer of kerosene that is added to the receiver when the instrument is installed for the purpose of preventing evaporation. Changes in the level of the water are communicated through a float and auxiliary mechanism to the recording pen in the manner explained above.

Although the gage may be continued in operation for eight days without requiring attention, yet occasional inspections during the period will avoid possible failure, as it can not be expected that the instrument will invariably give satisfactory service without attention.

Explanation of record.—Figure 4 shows a record sheet, the actual size of which is about 20 by 5½ inches over all when trimmed at the right-hand end ready to be placed on the cylinder. The vertical graduations on the sheet are spaced nearly 0.13 of an inch apart and correspond to 10 minutes of time; and the diagonal lines are spaced 0.10 of an inch apart and correspond to 0.05 of an inch of rainfall.

The graduations are of such size as to permit the record to be easily read, as will be seen by examining the illustration, figure 4. Take for example the rainfall recorded during the night of August 28, 1914. It will be noticed that "rain began" (RB) at 7:18 p. m., but from that time until 8:47 p. m. very little rain fell, as is evidenced by the line traced by the pen, which is very nearly parallel to the diagonal lines but which still has an upward tendency. A trace (T), or an amount too small to measure, is therefore entered for the hour ending at 8 p. m. At 8:47 p. m., however, the record line makes a decided bend upward, passes across four-fifths of the space in which it is moving (amounting to 0.04 of an inch of rainfall), and thence across two additional diagonal lines; all of which totals to 0.14 of an inch of rain up to the point where the record line crosses the vertical 9 o'clock line. Between 9 and 10 o'clock the pen made four complete oscillations with an additional movement of slightly more than two divisions (corresponding to 0.11 inch), making a total of 1.11 inches for the hour. During the next hour another heavy downpour occurred, the gage recording 1.12 inches within 32 minutes, after which time until 11:05 p. m. no appreciable amount fell. The storm terminated with an additional heavy fall amounting to 0.27 of an inch within a short period ending at 11:10 p. m., the rain finally ceasing altogether at 12:40 a. m. (RE), after recording 0.01 of an inch between 12:20 and 12:22 a. m. The total amount of rainfall for the entire storm is therefore 2.65 inches. The performance of the gage in recording lighter rains is shown by the record for the period from 4:04 p. m., August 25, to 8:55 a. m., August 26.

The observer should be careful to record the times of beginning and ending of rain by eye observations, making a written memorandum of the actual time of occurrence to be transferred to the record sheet when removed from the cylinder. The beginning of rain should be indicated by the letters "RB" (rain began), the ending by "RE" (rain ended), and the actual time checked on the sheet.

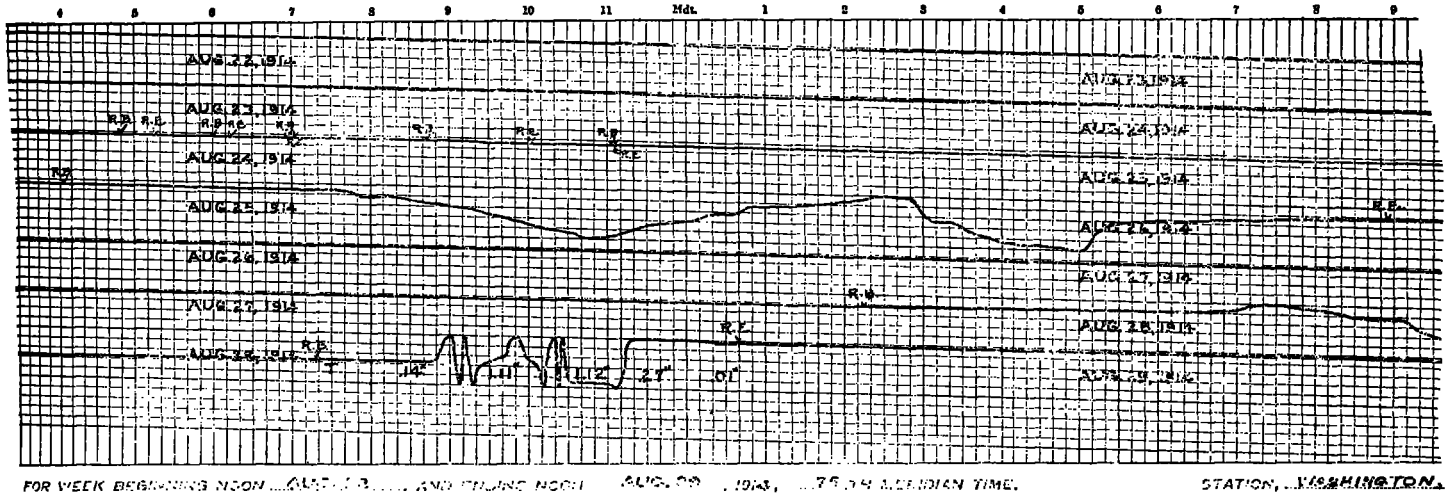

FIG. 4.—Sample of portion of record sheet from Marvin recording raingage. Record reduced to about one-half size and showing actual record obtained at the Weather Bureau, Washington, D. C. *RE*, rain began; *E E*, rain ended.

Insuring good record.—After operation of the gage has begun, there are several features to be considered in order that a good and continuous record may be insured, as follows:

1. The clock should be kept running to the exact time, as nearly as can be ascertained, and if adjustment becomes necessary, it will be accomplished in the usual manner by moving the small rod passing through the slot in the mounting plate, *P*, to the side marked *S* or *F*, to cause the clock to go slower or faster, respectively. If there is a time error, it should be noted on the record sheet when it is removed and the corrections applied to the several beginnings and endings of rain.

2. If, for any reason, the pen has not made a complete record the total amount may be determined by noting the number of lateral throws made by the pen while the water is being drawn out to its original or zero level, preparatory to placing a new record sheet on the cylinder. The amount thus determined should be indicated on the sheet together with a brief note of explanation giving the times of occurrence of rainfall if practicable.

3. To avoid needless friction about every second week, and oftener in a dirty location, the horizontal bars and screws, *I*, *U*, and *N* should be rubbed off with an oily rag so that there remains a clean but *slightly* oiled surface over which the pen carriage slides. The long screw with the pin and carrier can easily be removed by backing off the pivot screw, *V*, and all other parts should be thoroughly cleaned by use of kerosene or similar light oil. When cleaned these parts should be supplied with only the merest film of fine oil, and when replaced the pivot screw, *V*, should be set up so that there will be just a trifle of "end shake" to the screw, *N*. Occasionally the pivot bearings in the mounting plate and post should be given a *little* clock oil. The clock being inclosed should need but little attention and will be cared for in the customary manner.

4. Under no circumstances will the gage be left out in freezing weather, for if ice forms in the receiver or in the pipe leading thereto these parts are likely to be rendered unserviceable.

NEW METEOROLOGICAL STATIONS IN KOREA.

RAYMOND S. CURTICE, Vice and Deputy Consul General.

[Dated Seoul, Chosen, Jan. 21, 1915.]

It is reported that the authorities concerned have decided to establish during the fiscal year ending March 31, 1916, two meteorological stations and 25 meteorological offices for taking observations throughout Chosen. The plans of the authorities also include an increase of 25 offices during each fiscal year for the four years thereafter.